Invited review

Rehabilitation and treatment of spinal cord tumors

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Context: Due to advances in acute oncological treatment, patients with spinal cord tumors exhibit improved survival. However, these patients have not received the full benefits of rehabilitation services to address their neurological deficits and rehabilitation goals.
Objective: To evaluate the epidemiology and pathophysiology of spinal cord tumors, address methods of acute oncological management, review treatment for neurological sequelae, and understand the implications as they relate to rehabilitation.
Methods: An extensive literature review was performed regarding the epidemiology, pathophysiology, acute oncological management, neurological sequelae, and rehabilitation for patients with spinal cord tumors. Databases used included pubmed.gov and OVID, as well as individual journal and textbook articles.
Results: Access to treatment should be increased given improved survival and functional deficits for patients with spinal cord tumors. Individuals can benefit from inpatient rehabilitation programs, in spite of increased medical co-morbidity and neurological deficits. Specific areas of improvement include functionality, mood, quality of life, and survival. Adjustments to treatment plans must incorporate medical complications from cancer and its treatment, perceived quality of life, and prognosis.
Conclusions: Patients with spinal cord tumors who participate in rehabilitation programs show general improvement in function, mood, quality of life, and survival. Adaptations to care plans should be made to accommodate medical co-morbidities from cancer and its treatment, patient perceptions, and prognosis.

Keywords: Neurological manifestations, Recovery of function, Spinal cord neoplasms, Spinal cord injuries, Rehabilitation, Therapeutics, Quality of life

Introduction

The treatment of spinal cord tumors in the rehabilitation setting is challenging, when considering the functional deficits from spinal cord involvement, medical co-morbidity due to cancer, and individual life expectancy.[1] The primary goal of rehabilitation in this context is to improve quality of life and functional independence.[2] When combined with improvements in medical, radiation, and surgical oncology care, rehabilitation can serve to integrate patient and family efforts to improve function with a multidisciplinary team approach and prevent future complications from neurological compromise.[3] This is especially important given that a high percentage of patients with metastatic spinal cord compression are able to discharge to home.[4] Although life expectancy has improved for patients with spinal tumors due to both earlier detection and advances in oncological treatment, issues surrounding patient fragility and complications from concurrent medical treatment have prevented full access to rehabilitative services.[5] The purpose of this review is to understand the epidemiology, pathophysiology, acute oncological management, management of neurological sequelae, and rehabilitation implications for patients with spinal cord tumors.

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Epidemiology and pathophysiology

Metastatic spinal tumors are not uncommon, with over 18 000 new cases diagnosed yearly in North America and up to 70% prevalence in patients with cancer.[6] With 10% of new onset spinal cord injuries (SCI) due to tumor compression, cancer represents up to 26% of non-traumatic SCI admissions to inpatient rehabilitation units.[7] Tumors are defined by their point of origin, and are described in one of two ways. Primary tumors arise from the central nervous system (CNS) directly, whereas secondary or metastatic tumors spread from sites distant to the spinal cord; metastatic

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lesions accounts for 85% of all oncological SCI.[8] Primary tumors generally occupy the intradural and intramedullary space, but secondary tumors are typically extradural in nature. Although rare, secondary tumors can metastasize to intradural and intramedullary locations. The most common origins of secondary disease are lung, breast, kidney, prostate, and thyroid cancers, with bone serving as the third most common site of metastases and vertebrae the most common site of metastases in the bone.[9] Symptomatic lesions are most often diagnosed in the thoracic region presenting with motor incomplete paraplegia, though cadaveric studies have shown the most common site of vertebral tumor burden in the lumbar spine.[7]

Primary tumors of the spinal cord are less common than secondary tumors. Intradural tumors are extramedullary and mainly consist of meningiomas, neurofibromas, and Schwannomas, all of which are typically cured with surgical resection.[10] Intramedullary primary spinal cord tumors are relatively rare, accounting for 4–5% of all primary CNS lesions. Fifty-six percent of these tumors are described as benign, whereas 31% are considered malignant. Ependymomas and astrocytomas represent the majority of primary spinal tumors. Due to the rarity of these tumors, limited population-based incidence data exist that outlines prevalence by spinal levels and clinical outcomes.[11] These intramedullary tumors vary widely, with focal involvement of a few centimeters to diffuse entanglement along the entire length of the spinal cord. Low-grade astrocytomas and ependymomas have better rates of cure if completely resected, whereas high-grade astrocytomas have a poorer prognosis similar to that of glioblastoma multiforme (stage IV astrocytoma).[12] Patients with primary tumors who completed inpatient rehabilitation programs had a median survival of 9.5 months with 1-year survival of 47.4%, and 5-year survival of 10.5%, whereas patients with secondary tumors had a median survival of 2.8 months with 1-year survival of 21.4% and 5-year survival of 3.6%.[13]

The most common cause of dysfunction in secondary disease is extradural epidural cord compression. Two theories explain the mechanism by which tumor metastasizes. With tumor embolization, cancer cells can spread through the vascular system and deposit into the vertebral bodies. Bony lesions can be either osteolytic, which involves destruction of normal bone, or osteoblastic due to the deposition of new bone. Both types of lesions can cause vertebral body instability. The bony instability may lead to retropulsion of bony fragments into the epidural space after vertebral body collapse. In addition, the tumor itself may grow and impinge the thecal sac anteriorly, thus compressing the spinal cord and epidural venous plexus. An alternative mechanism may involve the spread of tumor cells directly via the pre-vertebral lymphatic system into the epidural space. Seeding can then progress along the subarachnoid space to the spinal cord. Lesions of the cervical and thoracic spine are most often the result of lung and breast disease, whereas lumbosacral involvement is most often due to prostate, colon, or pelvic involvement.[14] These are generally described as extradural lesions as they are located outside of the meninges. Survival rates are variable based on tumor pathology; lung metastases often yield the poorest survival rate, with 50% survival rate at 1 month and at best 16% after 24 months. Breast and prostate cancer have the best survival rates with 44% for breast and 25% for prostate after 24 months.[15] There is, however, a tail to survival curves and some patients may require high levels of long-term care for at least 3 years or more.[16]

Acute oncological management

Management of spinal tumors varies according to the stability of the spine, neurological status, and pain.[17] Treatment options mainly include surgical intervention, radiation therapy, and chemotherapy. Gross surgical resection of the tumor is recommended when possible, and has been shown to improve median survival rates by at least 6 months.[18] For lung cancer, postoperative performance status also yielded improved survival.[19] Indications for surgery include paraplegia lasting not more than 12–24 hours in patients with prior radiation to the spine, spinal instability, or bony compression of the spinal cord; ideally, radiation therapy should be considered as an adjuvant treatment as early as possible post-operatively and with a relatively short duration.[20] The primary goals for surgical management are to preserve neurological function and reduce pain, with as minimal intervention as possible to prevent further medical complications.[21] Potential problems from surgical intervention include respiratory complications, instrument failure, deep venous thrombosis, pulmonary embolism, cerebrospinal fluid leak, and wound infection and/or dehiscence, especially after adjuvant radiation therapy.[22] Although uncommon, myelopathy is a potential side effect of radiation therapy. It presents either acutely within 4–6 months, or is delayed by 1–2 years. Symptoms may include sensations of electrical shock within nerve root distributions, weakness and sensory loss below the level of radiation, and complete SCI with loss of sphincter control. Acute forms often resolve within a few months, whereas delayed versions are progressive and can be chronic.[23–25]

Certain primary spinal cancers, such as lymphoma, neuroblastoma, and germ cell tumors, are amenable to treatment with chemotherapy. Chemotherapy can also be used as an adjuvant therapy for secondary spinal disease, including breast, prostate, and myeloma metastatic to the spine.[26] For those patients with hormone-dependent paraplegia from prostate cancer, aggressive hormonal treatment with surgical decompression is recommended for treatment.[27] As part of a chemotherapeutic regimen, corticosteroids are often used to decrease oxidation injury and ischemic edema at the CNS level. Steroids are prescribed at high doses, with prolonged tapering schedules that decrease the overall dose by one-third to one-half every 4–5 days. Significant variability exists regarding the initial amount of dexamethasone and weaning schedule, but initial doses can range from 4 to 100 mg given every 6 hours. Noted side effects from high-dose steroid use include hyperglycemia, increased risk of infections, gastrointestinal irritation, mood disorder, fluid retention, and impaired wound healing.[26] Steroid-induced myopathy should also be considered if individuals develop proximal muscle weakness within a few days of steroid initiation; this risk has to be balanced with the potential positive effects of edema and pain control in the tumor patient.[28] It is often recommended to use gastrointestinal prophylaxis to limit possible ulceration with concurrent steroid use.

Acute oncological management can yield improved functionality in individuals treated for spinal cord tumors. For patients with good ambulatory status prior to surgery, surgical intervention offers the best potential to maintain ambulation status after intervention.[29] Positive prognostic factors for ambulation when receiving radiation therapy include treatment with glucocorticoids and intervention less than 12 hours after the loss of ability to walk; with improved ambulation status, patients generally experienced less pain. However, when individuals had more than one spinal epidural metastasis, they were less ambulatory.[30] Multivariate scale scoring may help predict ambulation status and survival when assessing similar positive prognostic factors.[31]

Although neurological injury from upper thoracic spinal tumors is common due to small spinal canal size at the cervicothoracic junction and tenuous blood supply to the affected area, surgical intervention yields improved Frankel grade classification by at least one level post-operatively and also pain symptoms.[32] Surgical intervention when combined with radiation therapy has shown gains regarding bladder dysfunction, the ability to void without an indwelling urinary catheter, and pain.[33] These combined effects are particularly important when complete surgical resection is not possible, as is the case for certain higher-grade intramedullary astrocytoma tumors.[34] For prostate cancer with metastases to the spine specifically, improvements in mobility, daily life activities, and sphincter control were noted after radiation therapy.[35] However, even with gross total resection, up to 20% of late-stage deterioration can be expected from tumor recurrence; symptoms may include spinal cord pain, impaired sensitivity, urinary sphincter dysfunction, sexual dysfunction, chronic motor disorders, and cord tethering.[36]

Management of neurological sequelae

Neurological complications from spinal cord tumors are secondary to spinal cord compression, plexopathy, or radiculopathy, and are the result of loss of neuronal pathways at or below the level of the lesion. Although these issues may be common to all patients with SCIs, some of these conditions may be further complicated due to the primary cancer or metastatic disease.[37]

Pain is reported to be one of the most common complications of neoplastic spinal cord compression.[37–39] It is the most frequent first symptom in patients with spinal cord compression due to cancer, and may present several months prior to neurological symptoms.[40,41] The pain initially fluctuates prior to becoming more constant, and is the result of vertebral lesions causing bony destruction, spinal cord compression, vertebral instability, or spinal nerve root impingement.[37] The quality and nature varies according to the location of the tumor.[2] For example, tumors causing impingement of a nerve root may cause radicular pain symptoms radiating in the distribution of the affected nerve root. Additionally, pain may be exacerbated by exercise, and has also been shown to have a major effect on a person's quality of life.[42–44] Several options are available for treatment including bracing for vertebral body stability, modalities (including heat, cold, ultrasound, and electrical stimulation), and medications. Although potential exists for metastatic spread of disease with modalities that promote increased blood flow, the clinical effects of pain relief may outweigh potential for tumor seeding especially if the disease process is significantly metastatic and tumor has already spread by different mechanisms. The World Health Organization outlines several medication treatment options, including non-steroidal anti-inflammatories, anti-convulsants, tricyclic antidepressants, steroids, and opioids.[45] Considerations should be made, however, for the side-effect profiles of each medication, as it relates to the individual's functional status and cancer diagnosis. For neuropathic pain specifically, both gabapentin and

pregabalin have been shown to decrease symptoms associated with spinal cord and nerve injury.[46–49]

Most spinal cord tumors cause upper motor neuron bowel dysfunction.[2] This may result in constipation and impaction due to inadequate emptying of the bowels.[50] Constipation can also be a common complication associated with opioid pain medication. This may be intensified by immobility and malnutrition, which can further exacerbate pain. A bowel program should be initiated to aid with effective bowel evacuation and prevent pain with defecation.[3,51,52] Medications should include stool softeners, stimulant laxatives, and suppositories combined with digital stimulation. Caution must be taken with digital stimulation due to increased risk of mucosal fragility, and digital stimulation is not initiated in patients with neutropenia or severe thrombocytopenia.[53] The goals of the program are to prevent incontinent bowel movements and to allow adequate evacuation of the bowels within 60 minutes of initiation.[54–57] For a bowel program to be effective, the program should be scheduled at a consistent time 30 minutes following a meal to take advantage of the gastrocolic reflex, and performed at least every 2 days.[50,57,58] Depending on the location of the tumor and cord compression, a reflexic bowel is a possible presentation of lower motor neuron bowel dysfunction. In this case, oral bulk forming agents are necessary to maintain firm stool in order to perform manual evacuation usually on a daily basis.[57] Again, special consideration to avoid digital manipulation of the rectal mucosa should be given in cases of neutropenia and severe thrombocytopenia.

Bladder dysfunction is a common late complication of spinal epidural cord compression and may present with various symptoms including urgency, frequency, retention, incontinence, and frequent urinary tract infections (UTI).[2,37] True neurogenic bladder may result in either lower or upper motor neuron symptoms due to suprasacral or sacral compression of the cord or roots. The goals of bladder management are to empty the bladder effectively, maintain adequate bladder pressures, prevent hydronephrosis and vesicoureteral reflux, sustain social continence, and reduce risk of kidney disease and UTI.[58] Full assessment of bladder function has been shown to improve continence by determining the most adequate means of bladder emptying. Methods for bladder management in this patient population include timed voiding, intermittent catheterization, and indwelling catheters.[37] Caution is again necessary with neutropenia and severe thrombocytopenia.

Decreased or absent sensation of the skin may increase the patient's risk of pressure ulcer development. Pressure ulcers can be worsened by moisture due to prolonged sitting and decreased mobility, bowel and bladder incontinence, and malnutrition. Pressure ulcers are preventable, and maintenance of skin integrity is vital.[2] Education of the patient should include appropriate techniques for pressure relief as well as information regarding the importance of nutrition.[2,59] Additionally, radiation treatments can cause increased skin fragility due to cell damage throughout the various layers of skin in which radiation passes. Radiation dermatitis is characterized by erythema, edema, and desquamation in early phases of exposure to radiation therapy. Late changes may include hair loss, telangiectasias, atrophy and fibrosis of the skin, loss of pigmentation, and ulceration. Gentle washing of the skin with water or soap and water within the field of radiation can decrease the risk of acute skin reaction.[60,61]

Sexual dysfunction may be the result of SCI, primary cancer itself, or oncological treatment effects. Both SCI and cancer may cause changes in body image, sensation, and function that may alter the person's perception of sexual attractiveness.[62,63] The rehabilitation program should include assessment of the patient's neurological injury and the impact of this injury on the patient's sexual response.[64] The extent of sexual dysfunction will be dependent upon whether the patient has complete or incomplete SCI. Further radiation therapy, chemotherapy, and depression may also affect sexual function. Assessment of the bulbocavernosous reflex (BCR) and completeness of an injury may help to understand an individual's capability for arousal.[64,65] Both psychogenic and reflexogenic erections are parasympathetic in nature, whereas psychogenic control may be possible through sympathetic nervous system stimulation.[66] For patients with complete SCI and absence of the BCR, the ability for reflexogenic erections and lubrication is diminished. Physiological orgasm is unlikely in patients with complete injuries with absence of BCR and anal wink reflex.[64,67] Treatment options for sexual dysfunction include education, counseling, oral medications, and assistive devices (such as vacuum device, intraurethral agents, and intracavernous injection therapy).[64]

Rehabilitation implications

In addition to SCI, it is important to understand the inherent medical co-morbidity associated with cancer diagnoses. Supportive care is essential to optimize an individual's medical status and improve the rehabilitation course.[68] Cancer-related fatigue is the most prevalent symptom experienced by individuals with cancer.

Evaluation and treatment of organic factors, such as anemia, are often easily correctable. However, other causes of fatigue must be considered, such as: depression; infection; metabolic factors from the tumor; radiation effects, including radiation-induced hypothyroidism and central effects from the radiation itself; sedation from centrally acting drugs and pain medications; and overall tumor burden. Although pain may be secondary to compressive and destructive mass effects, it may also be due to post-operative pain syndromes, radiation therapy, and chemotherapy. Patients are more susceptible to both anorexia and cachexia. Gastrointestinal tract disorders may include dysphagia after radiation, esophagitis, decreased motility from pain medications, and obstruction from tumor. Consideration should also be made for decreased caloric intake due to diminished appetite and malaise, competition between tumor and host for nutrients, and tumor-elaborated and -induced factors from paraneoplastic syndromes that could impair the desire to eat. Careful attention is needed to address disorders of mood, such as anxiety, depression, and delirium. These conditions are common in cancer patients, and may be secondary to the following: adjustment from diagnosis of a terminal condition; chemotherapy or radiation effects to the brain; intra-abdominal malignancy; hypercalcemia from bone involvement of the tumor; hypothyroidism as a side effect of radiation or chemotherapy; infections; nutritional issues, such as vitamin B_{12} deficiency; opioid pain medications; and organic dysfunction from direct CNS effects of the tumor. Dyspnea is also common. Factors that may affect breathing include: cachexia and wasting of the respiratory muscles, malignant ascites to the abdomen causing limited diaphragmatic excursion, metastatic disease to the lung, and poor premorbid medical status secondary to preexisting cardiopulmonary disease.[69]

Paraneoplastic syndromes are secondary to autoimmune responses to a primary tumor at a distant site, which then causes neuromuscular dysfunction. Common symptoms include cerebellar degeneration from ovarian carcinoma, myasthenic syndromes and myopathy from small-cell lung carcinoma, and myasthenia gravis from thymoma.[70] Infection is also common, and could be due to neutropenia from chemotherapy, concurrent steroid use, and hypogammaglobinulemia secondary to hematological disorders.[71] In cancer patients proximal deep venous thrombosis (DVT) is common, and patients are more likely to have greater initial tumor burden and greater clinical deterioration in spite of anticoagulation therapy. Risk factors for DVT include extrinsic vascular compression, obstruction of venous return due to invasion, blood flow stasis, endothelial injury, increased coagulation activity due to tumor release of pro-coagulant factors and inflammatory mediators, increased platelet aggregation, central venous catheter placement, and anti-neoplastic treatments.[72] Anemia is multifactorial and may be due to chemotherapeutic interventions which facilitate anti-mitotic mechanisms to slow down tumor growth but unintentionally decrease marrow production of red blood cells. Additional factors contributing to anemia involve vitamin deficiencies (such as iron, folate, and vitamin B12), chronic bleeding, renal insufficiency due to increased protein loads produced by the tumor, bone marrow suppression from tumor invasion, and chronic illness.[73]

Appropriate decisions for plans of care should account for acknowledgment of the phase of a patient's illness, likely gains from treatment, and potential for morbidity and toxicity with intervention.[74] With a diagnosis of spinal tumor, patients face a difficult adjustment due to denial of their disability, understanding new boundaries, concern about dependence on others, and learning to live within a new normality.[75] Quality of life may be inconsistent between that perceived by health care professionals and that perceived by the patient, and may be affected by both physical and non-physical issues, including independence, freedom from pain, and family support.[76] When designing a rehabilitation program, special attention is needed regarding individuals' perception of quality of life, which could be influenced by both spiritual well-being and level of education.[77] It is also important to have early discussion regarding advanced directives and resuscitation orders; less than half of patients at a major cancer center with metastatic spinal cord compression had a "do not resuscitate" note.[78] Even with improved survival and benefits from a rehabilitation plan of care, prognosis should still be an important factor when designing the goals of a rehabilitation program.[79]

Rehabilitation does have positive effects in patients with spinal cord tumors. Patients with benign tumors tend to have the most improved neurological recoveries.[80] However, individuals with malignancy have also shown overall improvements in function, mood, quality of life, and survival after inpatient rehabilitation. Over 84% of patients with neoplastic spinal cord compression were able to discharge to home. They maintained improvements in upper and lower extremity dressing, grooming, toileting, tub transfers, wheelchair use, ambulation, and stair climbing 3 months after

discharge.[37] Patients with American Spinal Asia Injury Impairment Scale A–C classification also experienced decreased pain, utilization of opioids, and measures of depression. They were more satisfied with life, and had better ability to transfer independently and manage bowel and bladder programs at home.[81] Appropriate bowel and bladder care is important to prevent major complications and discomfort from insensate skin due to neoplastic SCI.[82] Use of incentive spirometry, optimal nutritional supplementation, management of mood, and education in skin care issues contributed to an improved survival of 20 weeks.[83] Patients who survived greater than 1 year after discharge from inpatient rehabilitation experienced less medical complications, higher Frankel classification level (D), and decreased return admissions to the hospital.[84] Additional factors that could improve survival include less aggressive tumor pathology, slow progression of neurological symptoms, treatment with both surgery and radiation therapy, SCI as the presenting sign of malignancy, partial bowel control on admission, and partial independence regarding transfers at the time of admission to rehabilitation.[85] Longer-term survival for spinal cord malignancy has been noted for: total functional independence (FIM) measure score of 65 or greater on admission; Frankel classification of B, C, or, D; good wheelchair mobility; and good walking ability.[86] In contrast, patients with total FIM gain less than or equal to 13 had significantly poorer survival, though it has been noted that an increased length of stay did lead to higher overall FIM changes.[87]

When outlining a plan of care, it is important to understand that patients with spinal cord tumors may have to be assessed differently than patients with traumatic SCI. Patients with neoplastic cord involvement are generally older, female, and not employed; upon presentation they are incomplete and paraplegic with involvement at the thoracic levels, and have a decreased inpatient rehabilitation length of stay compared to traumatic injuries.[88] The primary source of cancer does not necessarily impact the functional evolution of individuals participating in rehabilitation programs, but accommodations have to be made based on concomitant cancer-related disorders, such as cachexia, fatigue, psychological factors, and adverse effects from primary treatment of the oncological process. Clinical evaluations must factor in how immobility, effects from pain medication, and malnutrition may affect gastrointestinal motility and nutrition. Unfortunately, due to the often incomplete nature of the injury, patients who use Valsalva maneuvers to trigger bowel movements may also suffer from significant back pain given spinal involvement of the tumor. In this patient population, it is not unreasonable to consider indwelling urinary catheters for patients who cannot void spontaneously or who have contraindications to receive intermittent catheterization, such as severe thrombocytopenia or leukopenia.[89] Patients with neoplastic spinal involvement may lack the ability to perform intermittent catheterization due to pain. Neurogenic complications from upper motor neuron lesions, such as detrusor sphincter dyssynergia and neurogenic detrusor overactivity, may make indwelling urinary catheter use appropriate in spite of increased risks of complications such as UTI or bladder calculi.[90] Of note however, for patients who complete inpatient rehabilitation with normal bladder function and survive greater than 1 month after discharge, 72% retained normal bladder function.[91] In addition, constant vigilance is needed regarding metabolic factors from the cancer itself, which can cause fatigue and can adversely affect neurologic tissue, thus causing both central and peripheral neurological deficits.[89] With concurrent malnutrition and effects from radiation, wound complications may pose significant problems.[92] Pressure sores that exist prior to the rehabilitation admission may also contribute to longer of length of stay due to wound care needs.[86]

Conclusions

As survival after treatment for spinal cord tumors improves, it is important to understand how to apply rehabilitation principles and practices to this patient population. Full access to treatment is still limited due to concerns about fragility and medical complexity associated with this diagnosis. Patients with spinal cord tumors can benefit from inpatient rehabilitation programs, in spite of their increased medical co-morbidity from the disease process itself, acute oncological management, and neurological sequela. Improvements have been shown in areas of functionality, mood, quality of life, and survival when participating in inpatient rehabilitation. Variations of traditional methods for care of the SCI patient are necessary to account for medical complications from cancer and its treatment, individual's perception of quality of life, and life expectancy.

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